

Readme for GOES X-ray Sensor (XRS) Measurements for GOES 8-15

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Important - The archived data for GOES 8-15 includes NOAA scaling factors which must be removed to get observed fluxes. To get observed fluxes from the archived data, users must divide short channel fluxes by 0.85 and divide the long channel fluxes by 0.7. (See Section 3 below.)

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1. GOES X-ray Sensor (XRS)

There are two X-ray Sensors (XRS) on each GOES satellite which provide solar X-ray fluxes for the wavelength bands of 0.5 to 4 Å (short channel) and 1 to 8 Å (long channel). The archived data comes from the NOAA Space Weather Prediction Center (SWPC).

2. Instrumentation

GOES 8-12 (GOES I-M series) and 13-15 (GOES NOP series) all have ion cell detectors and the detector/filter combinations make the spectral bandpasses nearly identical between both satellite series (and to earlier XRS detectors). The electronics are very different for the two series. The measurements agree across the full dynamic ranges except at the very lowest signal levels. The data are sampled at a 2-3 s time cadence (depending on satellite) and are binned to 1-minute averages.

3. Calibrations

To get observed fluxes, users must correct the data for the NOAA scaling factors, also referred to as 'fudge factors'. To get observed fluxes from the published data for GOES 8-15, divide the short band flux by 0.85 and divide the long band flux by 0.7. Scaling factors were initially implemented by SWPC to get

GOES-8 to agree with GOES- 7. GOES 7 was the last of the spinning GOES satellites while GOES 8 was the first of the 3-axis-stabilized satellites. The scaling factors were retained by SWPC so that flare warning levels correspond to consistent flux values; e.g., an M5 X-ray alert from SWPC is based on a flux level of $5 \times 10^{-5} \text{ W/m}^2$ for all satellites.

Some rocket launches have confirmed that the new sensors are accurate and that the scaling factors applied to match the old spinner satellites is not correct. However, because there has been no actual calibration and because the XRS is operational and there are many procedures and customers that depend on consistency more than accuracy, SWPC has not removed the scaling factors. GOES-R (launch about 2016) will have well calibrated detectors and will provide the confirmation needed to finally remove the scaling factors.

4. Bandpasses

For each sensor, the short wavelength cutoff is defined by the ion cell, while the long wavelength cutoff is defined by the thickness of the Be filter. Figure 1 shows the normalized detector responses for the short and long wavelength bands. The relative spectral contributions measured by the detectors extend further on the long wavelength edge as shown in Figure 2.

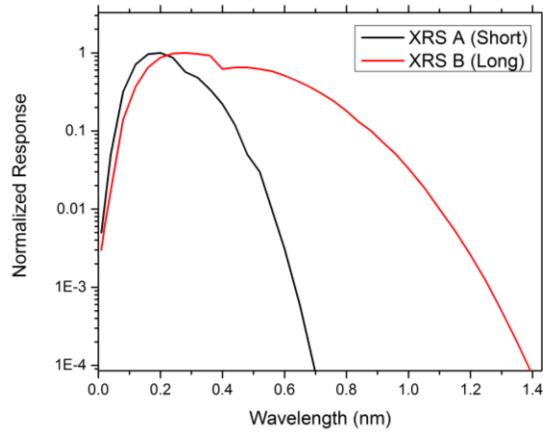


Figure 1. XRS detector responses.

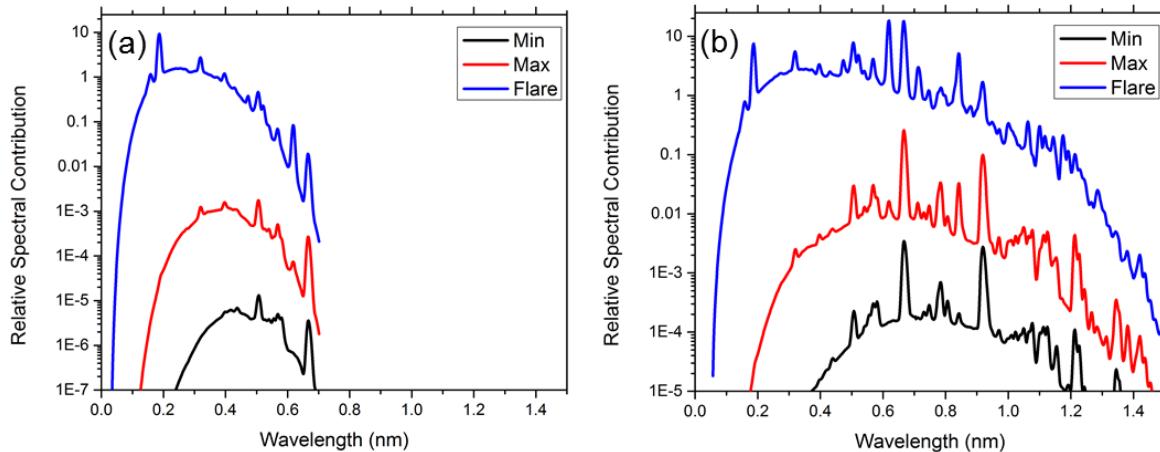


Figure 2. Relative spectral contributions for the XRS (a) short and (b) long channels. These are the detector responses multiplied by smoothed solar spectra for solar minimum, maximum, and flare conditions obtained from CHIANTI.

5. Data contamination

On rare occasions, when the X-ray sun is very quiet, bremsstrahlung contamination can be observed. This contamination is caused by energetic particles in the outer radiation belts and depends on satellite local time, time of year, and the local particle pitch-angle distribution. The X-ray sensors are also sensitive to background contamination due to energetic electrons that either deposit their energy directly in the telescope or strike the external structure and produce bremsstrahlung X-rays inside the ion chambers.

6. Detector saturation

During the most extreme flare events, the GOES XRS channels can saturate. As shown in Figure 3, during the 2003 Halloween storms, on GOES-12, the XRS long channel saturated at X-17 and the short channel saturated at X-5. There has not been a solar flare that saturated the XRS channels on GOES 13, 14 or 15 (as of October 2013), but it is expected that they will saturate at about the same flux levels.

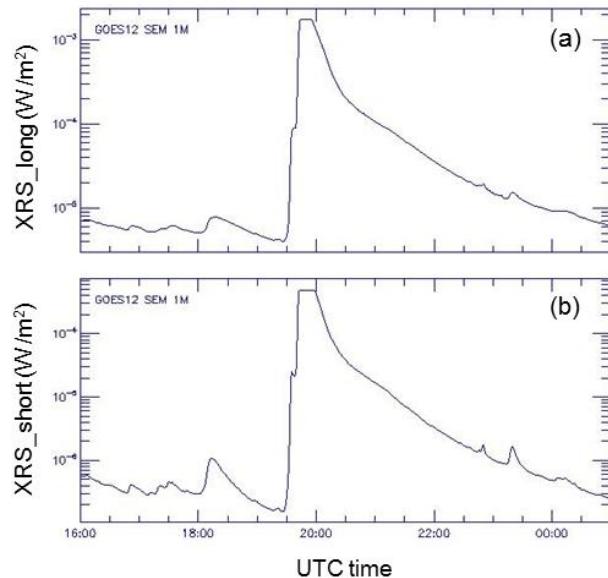


Figure 3. Example of the saturation of the long (a) and short (b) channels during a flare on 4 November 2003.

7. Data Access

Real time GOES XRS data is available from SWPC under "Instrument Measurements" at

<http://www.swpc.noaa.gov/Data/>

The archived GOES XRS data is available from the NOAA National Geophysical Data Center (NGDC) at
<https://www.ngdc.noaa.gov/stp/spaceweather.html>

At this page, click "GOES SEM" and then "Data Access." GOES XRS data is available for satellites GOES 8-15 (1995 to present) in NetCDF and CSV formats. Older satellite data are also archived.

8. Contacts

XRS data archive/access: sem.goes@noaa.gov
 XRS calibrations: janet.machol@noaa.gov

9. Calibration Data - GOES 13

This section provides calibration data for GOES-13. The tables and figures are from the XRS/EUV Data and Calibration Handbook for F1(SN003).

Table 1. Calibration data for GOES-13 Channel A.

Wavelength (nm)	Mu(Be) (cm**2/g)	Mu(Xe) (cm**2/g)	G(wavelength) (A-m**2/W)	Wavelength (nm)	Mu(Be) (cm**2/g)	Mu(Xe) (cm**2/g)	G(wavelength) (A-m**2/W)
0.01	0.1	1.16	1.167E-07	0.25	4.4	625	1.359E-05
0.02	0.1	7.23	5.798E-07	0.25899	4.8	660	1.310E-05
0.03	0.1	21	1.244E-06	0.25901	4.8	231	1.020E-05
0.035799	0.1	33.1	1.564E-06	0.26	4.9	232	1.012E-05
0.035801	0.1	5.94	6.948E-07	0.27	5.5	255	1.000E-05
0.04	0.1	8	9.296E-07	0.28	6.2	275	9.660E-06
0.05	0.1	14.7	1.674E-06	0.29	6.9	303	9.398E-06
0.06	0.1	24.3	2.694E-06	0.3	7.6	328	9.045E-06
0.07	0.1	37	3.963E-06	0.31	8.4	357	8.613E-06
0.08	0.13	53.2	5.443E-06	0.32	9.3	388	8.092E-06
0.09	0.19	73.1	7.065E-06	0.33	10.2	421	7.578E-06
0.1	0.26	97.1	8.780E-06	0.34	11.2	454	6.995E-06
0.11	0.35	126	1.053E-05	0.35	12.2	491	6.446E-06
0.12	0.46	159	1.217E-05	0.36	13.4	529	5.804E-06
0.13	0.59	197	1.367E-05	0.38	15.8	609	4.671E-06
0.14	0.74	239	1.493E-05	0.4	18.5	694	3.619E-06
0.15	0.91	275	1.566E-05	0.42	21.5	791	2.708E-06
0.16	1.1	327	1.649E-05	0.44	24.8	885	1.957E-06
0.17	1.3	383	1.705E-05	0.46	28.5	991	1.355E-06
0.18	1.6	447	1.725E-05	0.48	32.5	1090	9.081E-07
0.19	1.9	518	1.727E-05	0.5	36.9	1190	5.841E-07
0.2	2.2	592	1.711E-05	0.55	49.6	1500	1.630E-07
0.21	2.6	673	1.667E-05	0.6	65	1860	3.461E-08
0.22	2.9	762	1.632E-05	0.7	104	2740	6.831E-10
0.23	3.4	725	1.540E-05	0.8	157	3710	3.294E-12
0.24	3.8	792	1.485E-05				

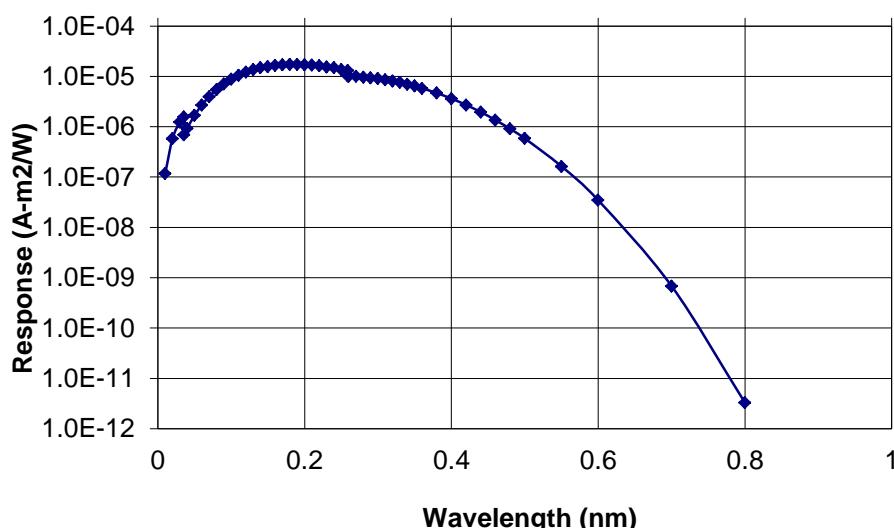


Figure 4. Calibrated response for GOES-13 Channel A.

Table 2. Calibration data for GOES-13 Channel B.

Wavelength (nm)	Mu(Be) (cm**2/g)	Mu(Ar) (cm**2/g)	G(wavelength) (A-m**2/W)	Wavelength (nm)	Mu(Be) (cm**2/g)	Mu(Ar) (cm**2/g)	G(wavelength) (A-m**2/W)
0.02	0.1	0.4	1.864E-08	0.5	36.9	296	4.036E-06
0.04	0.1	2.9	1.336E-07	0.52	41.7	328	3.952E-06
0.06	0.1	8.9	4.004E-07	0.54	46.9	363	3.836E-06
0.08	0.13	20	8.640E-07	0.56	52.5	399	3.689E-06
0.1	0.26	36	1.469E-06	0.58	58.5	438	3.520E-06
0.12	0.46	59	2.223E-06	0.6	65	479	3.330E-06
0.14	0.74	90	3.059E-06	0.62	72	522	3.124E-06
0.16	1.1	130	3.894E-06	0.64	79	568	2.925E-06
0.18	1.6	180	4.643E-06	0.68	95	667	2.498E-06
0.2	2.2	240	5.238E-06	0.72	113	778	2.078E-06
0.22	2.9	311	5.664E-06	0.76	134	903	1.671E-06
0.24	3.8	393	5.918E-06	0.8	157	1040	1.314E-06
0.26	4.9	489	6.038E-06	0.84	183	1187	9.998E-07
0.28	6.2	597	6.051E-06	0.88	211	1346	7.448E-07
0.3	7.6	720	6.002E-06	0.92	242	1516	5.376E-07
0.32	9.3	858	5.903E-06	0.96	275	1696	3.799E-07
0.34	11.2	1011	5.779E-06	1	311	1890	2.601E-07
0.36	13.4	1180	5.633E-06	1.04	351	2099	1.708E-07
0.38	15.8	1366	5.476E-06	1.08	393	2323	1.098E-07
0.38699	16.7	1435	5.419E-06	1.12	439	2561	6.766E-08
0.38701	16.7	153	3.730E-06	1.16	488	2813	4.040E-08
0.4	18.5	167	3.841E-06	1.2	540	3080	2.338E-08
0.42	21.5	189	3.966E-06	1.3	690	3800	4.824E-09
0.44	24.8	213	4.050E-06	1.4	860	4600	8.066E-10
0.46	28.5	239	4.088E-06	1.5	1050	5500	1.093E-10
0.48	32.5	267	4.086E-06	1.6	1270	6500	1.080E-11

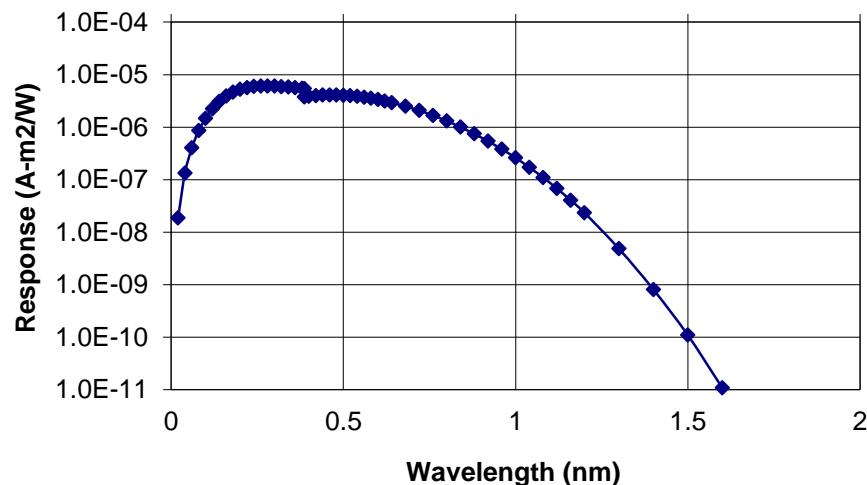


Figure 5. Calibrated response for GOES-13 Channel B.